

THE IDENTITY OF CULTIVATED *PHELLODENDRON* (RUTACEAE) IN NORTH AMERICA

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ABSTRACT

The identity and cultivation of the two species of *Phellodendron* (Rutaceae) in North America are reviewed. *Phellodendron amurense* is known to have escaped and naturalized in North America, especially in the northeastern USA. *Phellodendron chinense* is cultivated in gardens and arboreta, but has not escaped or naturalized yet. The differences between the two recognized species are provided, and the variability of the bark is also discussed. In addition, representative accession records of the cultivated specimens of *Phellodendron* in gardens and arboreta are provided.

RESUMEN

Se revisa la identidad y cultivo de dos especies de *Phellodendron* (Rutaceae) en Norte América. *Phellodendron amurense* se sabe que ha escapado y se ha naturalizado en Norte América, especialmente en el noreste. *Phellodendron chinense* se cultiva en jardines y arboreta, pero aún no se ha escapado o naturalizado. Se aportan las diferencias entre las dos especies reconocidas, y también se discute la variabilidad de la corteza. Además, se aportan citas de accesiones representativas de especímenes cultivados de *Phellodendron* en jardines y arboretos.

INTRODUCTION

Phellodendron, Rutaceae, is a small genus of ornamental, deciduous trees, with only two species, endemic to East Asia (China, Japan, the Korean Peninsula and the Russian Far East, Ma et al. 2006) where the bark and oil from its fruit are used medicinally (Huang Bo). Nearly 150 years have passed since *Phellodendron* was first introduced to the West in 1850–1860 (Rehder 1940; Read 1974; Bean 1976). Nonetheless, the nomenclatural status of the genus, especially in the horticultural field, is still confused today (Dirr 1998). For this study, published records of cultivated species of the genus were reviewed, available specimens were examined, major characters in cultivated specimens were analyzed, and the status of the alien species of *Phellodendron* in North America was clarified.

HISTORICAL REVIEW

The genus *Phellodendron* was completely revised first by Sargent (1905) based on the specimens at A and GH, and the living collections at the Arnold Arboretum of Harvard University; and a total of three species was accepted with fine illustrations of *P. amurense* Rupr. (Manchuria; Mongolia; C China), *P. sachalinense* (F. Schmidt) Sargent (Korea; Hokkaido, Japan) and *P. japonicum* Maxim. (Japan; Hubei and Sichuan, China). Sargent's revision has been cited as the classical history of the genus. However, because not enough specimens from the native area were available to his study, Sargent could do no better than earlier researchers; and, in fact, he created further confusion by identifying specimens from central China as both *P. sachalinense* and *P. japonicum*, a later described species (see below). Sargent also raised *P. amurense* var. *sachalinense* F. Schmidt to specific status as *P. sachalinense* (F. Schmidt) Sargent because he believed that it differed from *P. amurense* Rupr. in the darker color of the branchlets; the thinner, not corky, bark; the rufous, rather than silvery pubescent, winter buds; the leaflets not lustrous adaxially and glabrous along the margins; and the glabrous inflorescences. The species, *P. sachalinense* (F. Schmidt) Sargent, however, was treated as a synonym of *P. amurense* Rupr. in the modern *Flora of Japan* (Ohwi 1984; Ohba 1999).

In Rehder's Manual (Rehder 1940), an authoritative guide in the field of horticulture, five species of *Phellodendron* were recorded: *P. amurense* Rupr. from N China, Manchuria, introduced to North America in 1856, and cultivated in Hardiness Zone III; *P. sachalinense* (F. Schmidt) Sargent from Sghalin, Korea, N Japan, and W China, introduced to North America in 1877, and cultivated in Hardiness Zone III; *P. lavalleyi* Dode from C Japan, introduced to North America in 1862, and cultivated in Hardiness Zone V; *P. japonicum* Maxim. from C Japan, introduced to North America in 1863, and cultivated in Hardiness Zone IV; and *P. chinense* C. K. Schneid. from C China, introduced to North America in 1907, and cultivated in Hardiness Zone V. This work was completely adopted by another important horticultural manual (Bailey 1949), with fine illustrations of the leaves; and also adopted by the recent monumental work, *Garden Flora of Europe* (de Vries 1997). Based on these standard horticultural references for North America and Europe, different names have been used for living specimens in various gardens and arboreta, rather than the two names accepted here. Some were *P. piriforme* E.L. Wolf (e.g., Morton Arboretum record of 2004, #539-38, Arnold Arboretum Inventory of 2003, #1242-57 & 21607, Royal Botanic Gardens, Kew, Living Collection Database, #1938-13701, searched on March 28, 2003), which has never been effectively published (Ma et al. 2006), or *P. insulare* Nakai (e.g., Holden Arboretum Living Collection Database, #81-285, Royal Botanic Gardens, Kew, Living Collection Database, #1988-4479, searched on March 28, 2003, and Cornell Plantations Living Collections Database, #82-177, searched on March 25, 2004), which has never been accepted (Ma et al. 2006), or *P. lavalleyi* Dode (e.g., New York Botanical Garden Living Collections Database, #220/72, searched on March 27, 2004, Royal Botanical Garden Edinburgh Catalogue of Plants 2001, #19190039, Cornell Plantations Living Collections Database, #01-130, searched on March 25, 2004, Brooklyn Botanic Garden Living Collections Plant Inventory of 2004, #25008, 25009 & X00316, *The Plants of Pennsylvania*, Rhoads & Block 2000 and *Garden Flora of Europe*, de Vries 1997), which has never been accepted in its native flora of Japan (Ohba 1999) and worldwide revision (Ma et al. 2006). Some were even wrongly reported as *P. sachalinense* (Rhoads & Block 2000; McNamara and Pellett 2000 - the report, however, has been denied by the Junior author (Harold Pellett, pers. comm.). Pellett stated that "We do not have any *Phellodendron sachalinense* that we are confident of their identity. We think that the trees that we have in the Minnesota Arboretum are probably hybrids with *P. amurense* or some other species."

DIFFERENCES BETWEEN BARK OF NATIVE AND CULTIVATED TREES

There should not be much difference between the bark of the woody plants in cultivation and in their native habitats. However, this indeed happened in *P. chinense*. From measurements and observations of trees in their native habits, the two layers of bark of the two species could be easily distinguished (Ma et al. 2006): the outer bark of *P. amurense* is nearly $10 \times (1.12/0.37 \text{ to } 0.13/0.33)$ thicker than those of *P. chinense*. However in this study, all of the data of *P. chinense* from cultivated trees in northeastern North America are basically similar to those of *P. amurense* in its native habitat (see Table 1).

The ratio of outer to inter bark of *P. chinense* in cultivation is 1.56 to 0.92 (i.e., 1.7: 1), much larger than natural, wild populations (0.38: 1, Ma et al. 2006), approximately one half of the bark of *P. amurense* in wild (3.1: 1). Because *P. chinense* was from central and southwestern China where the weather is much warmer and wetter than the sites where it is in northeastern North America, the bark likely thickened in response to the colder temperatures, especially the outer layer, to protect the cambium. This indicates the plasticity of bark thickness of *P. chinense* in response to the environment (similar to Hedge et al. 1998s finding of variable bark thickness in response to disturbance in the western Ghats of India). However, no such change occurred in *P. amurense*, with its already thick, fissured bark (insulated from extreme temperatures, see Nikolai 1986) and grows in an area of East Asia, similar in climatic conditions to northeastern North America.

TAXONOMIC TREATMENT

Tree, deciduous, dioecious, 15–35 m high, 40–60(–100) cm in diam., usually with secretory cavities containing aromatic ethereal oils scattered throughout parenchymatous tissues. Bark corky, generally in two

layers: phloem (inner part), yellow, usually thickened with age, and cork (outer part), gray, usually thickened, dark, deeply striped or fissured along main trunk; lenticels white, slightly expanded on young branches; pith present, white or light brown to brown, round, continuous, sometimes spongy. Buds solitary, small, always hidden beneath leaf petiole, naked after leaves have fallen, pubescent, 2 per node, opposite. Leaf scars nearly encircling buds, 7–8 mm in diam., vascular bundle scars 3. Leaves odd-compound, opposite; estipulate; strongly aromatic, pellucid punctate along margin. Leaflets (7 or)9(or 11), mostly opposite, sometime alternate, or unequal at base; leaflet blade elliptic to ovate-oblong, symmetric, 21–32 × 13–16 cm, pilose when young or glabrous, but most becoming glabrous at maturity, base attenuate, sometimes slightly oblique, margin subentire or with minimal and fine serrulations not easily observed, apex acute or acuminate, sometime caudate, lateral veins pinnate, 6–11 pairs, mostly not prominent abaxially, curved forward to acute, again divided and disappearing before reaching margin; petiole 5.5–7.5 mm long. Inflorescences, a panicle 6.5–13.5 × 4.5–9 cm, loose or compact, nearly corymbose, terminal or opposite to young stem, with many flowers in several clusters, clusters opposite or nearly so; peduncle 4–8.5 cm long, without scales or pubescent, branching or not. Flowers: male: 5-merous, sepals 5, petals 5, stamens 5, anthers yellow, globose, ca. 1 mm long and in diam., 2-lobed, longitudinally dehiscent, disc small, around pistillode, pistillode clavate, white pubescent at apex; female: 5-merous, sepals 5, petals 5, staminode clavate; carpels 5, ovary 5-locular, ovule 1 per locule, style very short or nearly absent, stigma capitate, 5-lobed, much shorter than ovary, persistent. Fruit a drupe, black, 8–9.4 × 7.5–8.7 mm, subglobose, 5-locular, stone-like, glabrous, most with 5 grooves and angles when dry; fruiting pedicel ca. 0.4 mm long. Seed 1 per locule, brown, sometimes with black pits, ellipsoid, to 4.5 × 2.5–3 mm, slightly compressed, shiny; endosperm oily, cotyledons flattened, embryo straight; germination epigeal.

KEY TO THE SPECIES OF *PHELLODENDRON*

1. Panicle 8.5–13.5 × 6.5–9 cm, loose, peduncle 5–8.5 cm long, branches at least 1 cm long; tree, 25–35 m high (cultivated in North America, Europe, Australia, New Zealand, and northern Asia) _____ **1. *P. amurense***
1. Panicle 6.5–9.5 × 4–6.5 cm, compact, peduncle 4–6 cm long, unbranched or nearly so; tree, 15–20(–25) m (cultivated in North America and Europe) _____ **2. *P. chinense***

1. *Phellodendron amurense* Rupr., Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Petersbourg Ser. 2, 15:353. 1857.

Phellodendron amurense Rupr var. *angustifolium* E.L. Wolf, *P. amurense* var. *japonicum* (Maxim.) Ohwi, *P. amurense* Rupr var. *latifolium* E.L. Wolf, *P. amurense* var. *lavalleyi* (Dode) Sprague, *P. amurense* var. *molle* (Nakai) S.H. Li & S. Z. Liou, *P. amurense* f. *molle* (Nakai) Y.C. Zhu, *P. amurense* var. *sachalinense* F. Schmidt, *P. amurense* var. *wilsonii* (Hayata & Kaneh.) C.E. Chang.

Phellodendron insulare Nakai

Phellodendron japonicum Maxim.

Phellodendron kodamanum Makino

Phellodendron lavalleyi Dode

Phellodendron macrophyllum Dode

Phellodendron molle Nakai

Phellodendron nikkomontanum Makino

Phellodendron piriforme E. Wolf

Phellodendron sachalinense (F. Schmidt) Sargent, *P. sachalinense* Rupr. var. *suberosum* (H. Hara) H. Hara, *P. sachalinense* (F. Schmidt) Sarg. var. *suberosum* H. Hara

Phellodendron wilsonii Hayata & Kaneh.

Phellodendron amurense was introduced in the 1850s to the West (Rehder 1940). By 1874, it was cultivated at the then two-year-old Arnold Arboretum of Harvard University (Goodale 1877; Roca-Garcia 1970; Del Tredici 1995). Since then the tree has been reintroduced into the Arboretum many times from different countries (China, Japan, and Russia, especially 1900–1920s) until later years of the 20th century (Rehder 1940; Anonymous 1971). By 1910, the tree was cultivated both in Europe and in North America, at such

TABLE 1. Bark thickness of *P. chinense* cultivated in northeastern North America

Arboretum Name	Inventory No.	CR	OLB	ILB	Voucher*
Morton Arboretum	V57-55-30	230	2.8	1.5	<i>J.S. Ma 5101</i>
Morton Arboretum	V57-80-85	140	2.2	1.4	<i>J.S. Ma 5100</i>
Arnold Arboretum	6963-2A	132	0.8	0.5	<i>J.S. Ma 5116</i>
Arnold Arboretum	55-55C	203	1.2	0.6	<i>J.S. Ma 5117</i>
Dawes Arboretum	s.n.	138	0.8	0.6	<i>J.S. Ma 5107</i>
Average:		168.6	1.56	0.92	Ratio: 1.7: 1

*: CR: Circumference of trunk at DBH, OLB: outer layer of bark, ILB: inner layer of bark; all voucher specimens are deposited in BKL, all measurements are in cm.

places as Royal Botanical Garden Kew of England, Breslau, Poland, the USDA Bureau of Plant Industry, Glenn Dale, Maryland, the Arnold Arboretum, Massachusetts, and Cornell Plantations, New York. Among them, the Arnold Arboretum played a very important role for redistributing the species, especially in North America. By the 1930s, it had been collected from California, Michigan, New York (Grier and Grier 1928), Ohio, Pennsylvania, Washington D.C. and Canada, and now, it is widely planted in more than 20 states within the USA (USDA Hardiness Zone 3–7(–8); Schopmeyer 1974; Dirr 1998; Hensley et al. 1991; Jacobson 1996; also see Fig. 1). Gardens and arboreta in Russia also played a very important role in the spread into European gardens and arboreta, nurseries, and parks (Bean 1976).

Because *P. amurense* recently has been considered an invasive alien in northeastern North America (Hao et al 2004; Glaeser & Kincaid 2005; Invasive Species Initiative 2005; Invasivespecies.gov 2005), some cultivated plants have been removed, e.g., at Dawes Arboretum, all female trees had been cut down when the author visited in spring 2004). This kind of action, however, may go too far because the species has only escaped and become naturalized in only a few places in northeastern North America (<http://plants.usda.gov/>), around the vicinity of gardens, arboreta, or parks in urban areas, or along residential roadsides where they were planted, e.g., in New York City (Anonymous 1991; Anonymous 1995; Glaeser & Kincaid 2005). Among the specimens examined for this study, all were collected in residential areas or urban habitats even though it was reported as becoming invasive in the larger New York Metropolitan area (Greller 1977; Grellier & Calhoun 1979; Mitchell 1999; 2001; Lamont & Young 2002; Glaeser 2005; Glaeser & Kincaid 2005), e.g., New York Botanical Garden (Cruz & Nee 2003; Small & Alexander 1933) and Forest Park, Queens Co., New York City (Anonymous 1961). Although, seeds of *P. amurense* possibly require a dormant period for germination (Starshova 1979; Zhu & Dong 1990; Mizui & Kikuzawa 1991; but see Read 1974), there are no reports about this from the natural areas in northeastern North America. Therefore, it cannot be treated as an invasive species if we accept recent concepts of naturalization and invasion of alien plants (Richardson et al. 2000; Pysek et al. 2004). Furthermore, there has been no damage reported to the native flora even though the potential exists for *P. amurense* to become an invasive in the future, especially in northeastern North America (Massachusetts Invasive Plants List 2005).

Original distribution.—Mixed forests, below 2500 m: China (Beijing, Hebei, Heilongjiang, Jilin, Liaoning, Nei Mongol, Shandong, Taiwan: 2,000–2,700 m), Japan, Korea, and the Russian Far East.

Cultivated distribution.—**CANADA:** British Columbia, Ontario. **USA:** California, Colorado, Connecticut, Delaware, Georgia, Illinois, Indiana, Kansas, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Tennessee, Virginia, Washington, Washington DC; also in Australia, Belgium, the Czech Republic and Slovakia, Denmark, England, Estonia, Finland, France, Germany, Hungary, Ireland, the Netherlands, New Zealand, Norway, Poland, Russia, Scotland, and Spain.

Cultivated specimens studied: **CANADA. BRITISH COLUMBIA. Vancouver:** Elizabeth Park, 14 Jun 1988, *G.B. Straley 4809* (MOR, NA). **ONTARIO. Ottawa:** Central Experimental Farm Campus of Brockport, 8 Jun 1974, *W.I. Illman cco19082* (NYS); Dominion Arbo-

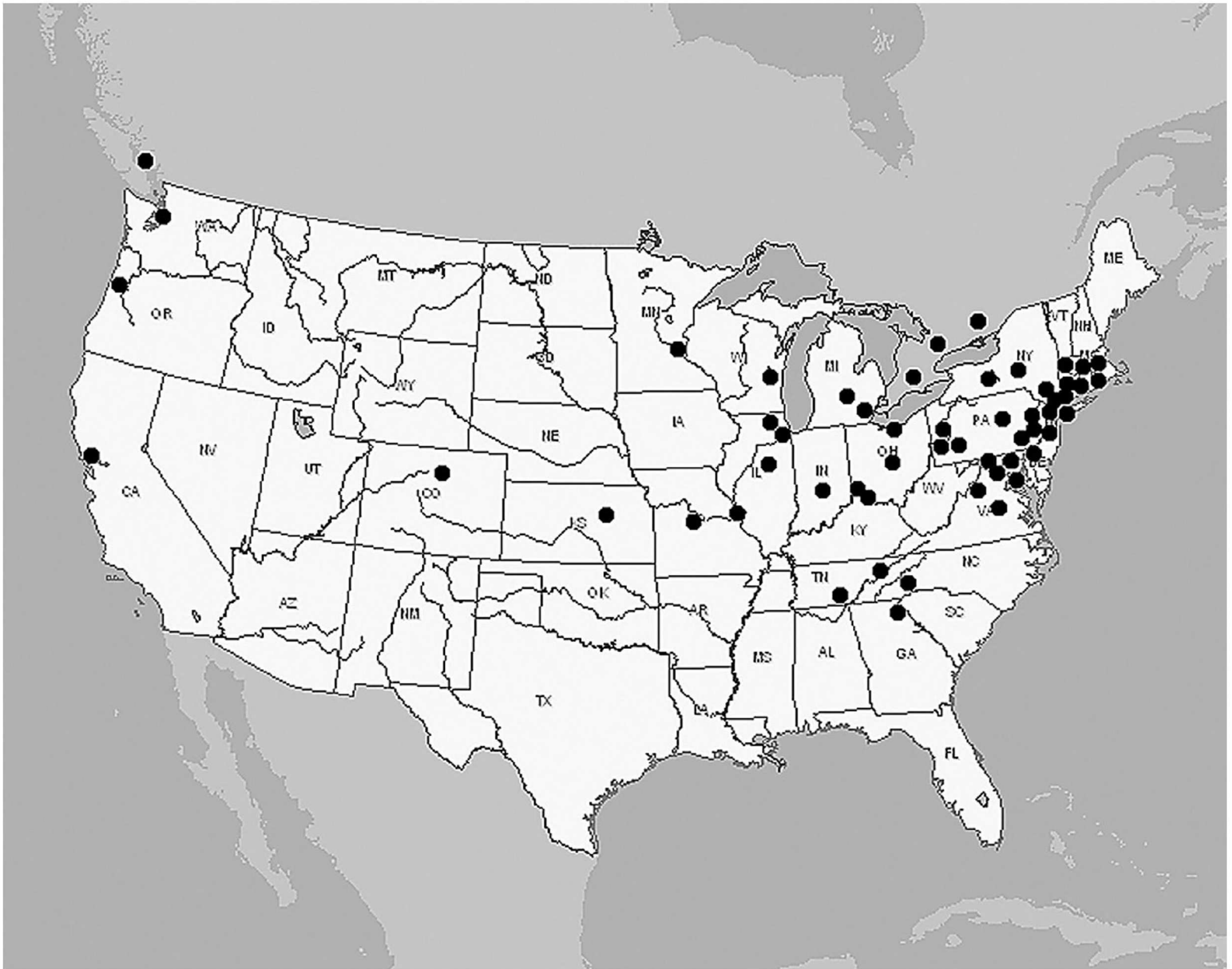


FIG. 1. Map of cultivated collections of *Phellodendron amurense* in North America.

retum and Botanic Garden, #120646, 10 Jul 1939, J.M. Gillett X-2-257 (NA), 29 Aug 1939, fruit, G.H.M. Lawrence 778 (BH); 10 Jul 1939, H.A. Senn 1940 (BH).

U. S. A. CALIFORNIA. San Francisco Co.: Golden State Park, 20 May 1933, E. Walther s.n. (A); University of California Davis, 2 Aug 1972, H. Fong s.n. (CM). **CONNECTICUT. Fairfield Co.:** Hill Road, 9 Apr & 20 Aug 1941, flower & fruit, E.H. Eames s.n. (CONN); Sherman, Turner Mt., Caretakes's Lodge, 28 Jun 1989, M. Ardwin s.n. (CONN); **Litchfield Co.:** Salisbury Southeast side of Prospect Mt., 23 May 1985, L.J. Mehrhoff 11350 (CONN); 10 Oct 1985, fruit, 11792 (CONN). **Tolland Co.:** Storrs, Mountain Road and Rte 44, 20 Oct 1999, fruit, B.A. Connolly 42 (CONN); 23 May 1969, M. Lefor & F.H. Wolfe 647 (BH, MASS). **DELAWARE. New Castle Co.:** Greenville, Cuba Botanical Park, 6 Jun 1968, Cuba Botanical Park Herbarium 115 (A, K). **GEORGIA. Cherokee Co.:** Reinhardt College Campus, 4 Jun 1983, F.G. Meyer & P.M. Mazzeo 19708 (A, CM, MOR, NA). **ILLINOIS. Champaign Co.:** 31 Aug 1970, R.A. Evers 103534 (A), 18 Oct 1998, fruit; S.R. Hill 31181 (NY); 17 May 1972, B. Nelson, B. Little & C. Crist 602 (A). **Cook Co.:** 9 Jul 1983, fruit, L. Nee, 27451 (F). **DuPage Co.:** Lisle, Morton Arboretum, 15 Jun 1995, K. Altvatter & J. Hammond 7115V95 (F); 19 Jun 1995, fruit, 7134V95 (F, seed from Botanischer Garten und Botanisches Museum Berlin-Dahlem, Berlin); 11 Oct 1994, fruit, B.K. Altvatter & P. Steinhouse 6901V94, 358-25 (F, seed from Arnold Arboretum); 3 Aug 2001, W. Hess & K. Allen 9688 (F, NY); 18 Jun 1997, G. Hickman & J. Pinkard 7926V97 (NA); 9 Jul 1998, S.K. DeMink s.n. (F); 10 Oct 1998, fruit, thick cork bark, R.D. Hyerczyk 1598 (MOR); 10 Oct 1998, fruit, 1601 (NA); 7 Sep 1998, D.S. Kirt 475-32 (NA); S.N. Kobal 95-14 (MOR); 7 Aug 1987, F.A. Swink 7406 (MOR); 30 Sep 1992, G. Wilhelm s.n. (MOR); Will, Pilcher Park-Joliet Park District, 10 Oct 1998, fruit, R.D. Hyerczyk 1601 (MOR). **INDIANA. Monroe Co.:** Bloomington, Indiana University Campus, 29 Jul 1949, fruit, R.B. Ledin s.n. (CONN). **MARYLAND. Baltimore Co.:** Carroll Park, 15 May 1979, F.G. Meyer & R. Fisher 17479 (NA); 15 May 1979, 17480 (A); Charles, Bryans Farm, 27 Sep 1975, fruit, F.G. Meyer 15282 (NA); 3 Jul 2000, fruit, B.W. Steury 7036 (NA). **Prince George's Co.:** Glenn Dale, USDA Bureau of Plant Industry, 20 Sep 1906, I. Tidestrom 1805 (NA). **Montgomery Co.:** Silver Spring, 11 Aug 1975, F.G. Meyer & P.M. Mazzeo 15262 (NA). **MASSACHUSETTS. Hampshire Co.:** Amherst, University of Mass., 18 Sep 1966, fruit, H.E. Ahles 64704 (MASS 2 sheets); 1 Jul 1969, fruit, A.C. Gibson 965 (A); S.R. Hill 16999 (NY); 12 Oct 1940, R.E. Torrey s.n. (MASS); 8 Jun 1945, s.n. (MASS); 29 Aug 1946, fruit, s.n. (GH, MASS); 6 Jun 1951, R.E. Torrey & E. Putala s.n. (MASS); Holyoke

Range, South Hadley, 12 Sep 1999, K.B. Searcy 52 (MASS); Northampton, Smith College, 21 May 1969, A.C. Gibson 362 (A), Reading, Jun 1879, W.H. Manning s.n. (BH). **Norfolk Co.:** Brookline, 1 Sep 1965, Baldini s.n. (A 2 sheets). **Suffolk Co.:** Jamaica Plain, Arnold Arboretum, 16 Jun 1960, fruit, B.K. Boom 40329 (L, from Japan in 1905); 16 Jun 1960, 40331 (L, collected by Wilson from Japan in 1919); 16 Jun 1960, 40332 (L); 16 Jun 1960, fruit, 40338 (L), 27 Jun 1917, H.H. Chung 5251 (PE 2 sheets); 23 Oct 1979, fruit, K. Clausen, S. Davis, C. Warren & M. Awolcott 79168 (BM); 20 Aug 1904, fruit, E.J. Cole s.n. (A, MICH); 8 Jun 1980, S. Davis, C. Warren & M. Wolcott 80-201-B (BH, F, PE, raised from seed of Wilson 11263, 17 Feb 1919 from Japan); 9 Jun 1982, fruit, S. Davis et al. 558 (A, BH, F, from Arnold Arboretum #7544-C, seed from J. G. Jack, Azuma, Japan, 15, Dec 1905); 15 Sep 1982, fruit, S. Davis & M. Wolcott 566 (A, BM, BH, F, from Arnold Arboretum #7544-C, seed from J. G. Jack, Azuma, Japan, 15, Dec 1905); 18 Aug 1960, fruit, T.R. Dudley s.n. (A); 10 Aug 1984, fruit, S. Elsik, B. Mackenzie, A. Kosmidis, & L. Stockman 1655 (A, BH, Arnold Arboretum #646-66-A); 30 May 1986, 4269 (A, BH, Arnold Arboretum #401-56-A); 30 May 1986, 4270 (A, BH); 30 May 1986, 4280 (A, BH, Arnold Arboretum #13232-B); 25 Jun 1969, fruit, A.C. Gibson 868 (A, Arnold Arboretum #12202-1-B); 25 Jun 1969, fruit, 869 (A, Arnold Arboretum #13232-A); 25 Jun 1969, fruit, 870 (A, Arnold Arboretum 13232-B); 25 Jun 1969, fruit, 873 (A, Arnold Arboretum #7544-c, from J. Jack 1905, Japan); 5 Sep 1985, fruit, S. Elsik, G. Good & K. Groves 3407 (A, Arnold Arboretum #362-54-A, seed from Japan in 1952); 5 Sep 1985, 3417 (A 2 sheets, Arnold Arboretum #1242-57-A); 21 Oct 1986, fruit, S. Elsik & R. Zinman 4866 (A, Arnold Arboretum #646-66-B, from J.G. Jack s.n. 3 Nov 1919); 18 Jul 1913 & 17 Oct 1920, C. Schneider 142-15 (BKL 2 sheets); 15 Nov 1908, fruit, 143-17 (BKL); 17 Oct 1915, fruit, 4961-1 (BKL); 17 Oct 1918, s.n. (BKL); 18 May 1926, s.n. (BKL); 15 Sep 1930, fruit, s.n. (BKL); 15 Sep 1922, H. Teuscher s.n. (A 8 sheets, MOR, #143-6 from Bot. Garden Petersb. in 1874); 18 Jul 1914, fruit, L.G. Hornby s.n. (MICH); 7 Jun 1927, N. Judd s.n. (A, Arnold Arboretum #1008-26); 9 Sep 1931, Kobuski & Ronsh s. n. (A 2 sheets, Arnold Arboretum #150-28, from 143-6, 1928); 8 Sep 1931, s.n. (A, Arnold Arboretum #1008-26, 2nd exp. Farrie, 1926); 4 Sep 1985, D. Michener & S. Elisk 3403 (A, BH, Arnold Arboretum #389-68-A); 3 Jun 1936, E.J. P. s.n. (A, BH, Arnold Arboretum #143-9-B), Jun 1937, s.n. (A, MOR, Arnold Arboretum #7544, seed from J. G. Jack in Azuma, Japan, 1905); 3 Jun 1936, s.n. (A, BH, MOR, from #21607-A, seed of Bot. Inst., Leningrad, USSR in 1926); 17 Sep 1936, fruit, s.n. (A 4 sheets, MOR, from #12202-1, Grafted from #12202, Arnold Arboretum in. 1919); 17 Sep 1936, fruit, s.n. (A, #19480-D, seed from Bot. Gard., Muenchen, Germany in 1925); 17 Sep 1936, fruit, s.n. (A, #19481-C, seed from L. Spath, Berlin, Germany); E.H. Wilson 876 (A); 11 May 1904, C.S. Sargent s.n. (A); 6 Jun 1973, L. Segal & A. Thompson 71 (A, Arnold Arboretum #12202-1-A); 5 Oct 1922, H. Teuscher s.n. (MOR, Arnold Arboretum #10724, E.H. Wilson 11263, seed collected by Wilson, from Taiwan (Formosa) in 1919); 29 May 1986, R. Zinman & J. Carey 4264 (A, BH, Arnold Arboretum #1244-57-A); Somerville, Tufts University Campus, 5 Aug 1998, fruit, NHN/EGM/APC s.n. (CONN); Wellesley, 2 Aug 1972, fruit, S.A. Spongberg & H. Clement 72-51 (A, BM). **MICHIGAN. Washtenaw Co.:** Ann Arbor, University of Michigan Arboretum, 7 Oct 1931, fruit, J.H. Ehlers 4999 (MICH). **Clinton Co.:** East Lansing, Michigan State University Campus, 8 Jun 1979, W.T. Gillis 15109 (CONN). **MISSOURI. Boone Co.:** Columbia, Missouri University Campus, Summer 1960, fruit, W. Campbell s.n. (MOR). **St. Louis Co.:** St. Louis, Missouri Botanical Garden, 21 Aug 1989, fruit, M.T. Crosby 84 (TI, #U-5780); 26 Jul 1974, fruit, J. Slama 38 (A, BH). **NEW YORK. Bronx Co.:** Bronx, New York Botanical Garden, 1937, L. Croizat s.n. (NY 5 sheets); 11 Jul 1923, fruit, A.S. Foster s.n. (BH); 1909, fruit, H. Hallier s.n. (L); 26 Jul 1929, H. Moldenke 4926 (NY); 16 Aug 1995, fruit, C. Morenberg 115 (NY); 30 Aug 1980, fruit, S. Mori 13639 (NY); 29 May 1994, 23700 (NY); 5 Jul 1993, fruit, M. Nee 43585 (BH, NY); 30 Sep 2003, fruit, 52592 (NY); 3 Oct 2003, fruit, 52593 (NY); 4 Oct 2003, fruit, 52594 (NY); 5 Oct 2003, fruit, 52595 (NY); 8 Oct 2003, fruit, 52596 (NY); 10 Oct 2003, fruit, 52597 (NY); 10 Oct 2003, fruit, 52598 (NY); 11 Oct 2003, fruit, 52599 (NY); 11 Oct 2003, fruit, 52600 (NY); 13 Oct 2003, fruit, 52601 (NY); 13 Oct 2003, fruit, 52602 (NY); 23 Sep 2003, fruit, 52950 (NY); 18 Jun 1931, fruit, P. Wilson s.n. (NY). **Kings Co.:** Brooklyn, Brooklyn Botanic Garden, 6 Aug, 1979, fruit, T.J. Delendick s.n. (BKL); 25 May 1982, fruit, s.n. (BKL 5 sheets); 25 May 1982, s.n. (BKL 3 sheets); 26 May 1982, s.n. (BKL 2 sheets); 26 May 1982, s.n. (BKL 6 sheets); 26 May 1982, s.n. (BKL 5 sheets). **Nassau Co.:** 8 Jul 1997, S.D. Glenn 2777 (BKL, NYS); 25 Aug 1995, D. Kunstler s.n. (BKL). **Ontario Co.:** Geneva, New York Agricultural Experimental Station, 19 Aug 1921, fruit, F. Blank s.n. (BH). **New York Co.:** Central Park, 12 Sept 1914, E.B. Jaultiruck s.n. (BKL 2 sheets). **Orange Co.:** Sterling Forest, 5 Jul 2000, fruit, R.S. Mitchell 10751 (BKL); fruit, 11 Sep 2004, G. Moore, T. Delius & J.S. Ma 6864 (CONN); Scarborough, 31 Nov 1895, fruit, W.H. Manning s.n. (BH). **Somerset Co.:** 25 May 2000, S.D. Glenn 4161 (BKL). **Suffolk Co.:** Islip, along LIRR, 27 Jul 1994, S.D. Glenn 48 (BKL). **Tompkins Co.:** Ithaca, Cornell University Plantation, 7 Oct 1946, fruit, M.W. Allen s.n. (BH 2 sheets); 23 Jun 1890, fruit, L.H. Bailey s.n. (BH); May 1985, fruit, H. Banks s.n. (BH); 9 Oct 1941, S.H. Burnham s.n. (BH 2 sheets); 24 Oct 1940, fruit, J. Comman s.n. (BH 2 sheets); 16 Jun 1904, J.E. Coit s.n. (BH) & fruit, 25 Aug 1904, s.n. (BH); 24 Aug 1952, fruit, A.J. Eames s.n. (BH); Summer 1946, fruit, A. Schulze s.n. (NYS). **Westchester Co.:** Yonkers, 20 Jun 1938, seedling, H.N. Moldenke 10600 (BH, NY). **NORTH CAROLINA. Buncombe Co.:** Biltmore, 19 Jul 1894, W.H. Manning s.n. (BH); 27 May & 2 Aug 1898, flower and fruit, S. P. 7086 (F, NY). **OHIO. Butler Co.:** Oxford, 27 May 1993, M.A. Vincent 5894 (NA). **Hamilton Co.:** Cincinnati, Mt. Airy Forest Park, 10 Oct 1934, fruit, E.G. Hutchinson s.n. (BH). **Cuyahoga Co.:** Cleveland, Gordon Park, 5 Jun 2000, G. Wilder & M. McCombs 13672 (MICH). **Franklin Co.:** Columbus, Ohio State University, 10 May 1967, J.F. Cooke & R.L. Stuckey s.n. (A, NA). **OREGON. Ravalli Co.:** Corvallis, Oregon State University, 3 Jun 1968, J. Dennis 2931 (A). **PENNSYLVANIA. Allegheny Co.:** Pittsburgh, Highland Park, 26 Jun 1961, M. Armbruster s.n. (CM); 17 May 2002, B.L. Isaac & J.A. Isaac 14339 (CM 2 sheets); 14 Oct 1973, V. Phelps, s.n. (CM); 27 Aug 1937, R.J. Templeton & J.R. Steck s.n. (CM); Pittsburgh, 17 May 2002, A. Rhoads s.n. (MOAR); 24 Oct 2004, s.n. (MOAR). **Berks Co.:** 14 Jun 1968, fruit, W.C. Brumbach 6262 (A); 14 Jun 1968, fruit, 6271 (A); 22 May 1969, 6763 (A, NA, NY); 11 Aug 1971, fruit, 7644 (A, NY). **Bucks Co.:** 12 Aug 1998, A.F. Rhoads & T.A. Block s.n. (MOAR); 6 Aug 1980, fruit, A.E. Schuyler 5481 (PH). **Delaware Co.:** Haverford College, 17 May 1942, P.T. Haas s.n. (PH); 28 Aug 1995, fruit, 28 Jul 1941, s.n. (BKL, PH); 11 Oct 1933, E.J. P. s.n. (A, Arnold Arboretum #972-34). **Lancaster Co.:** Elizabeth, 16 Jul 1930, E.M. Gress s.n. (PH). **Leigh Co.:** Allentown, 26 May 1956, R.L. Schaeffer, Jr. 50574 (PH); 22 May 1959, s.n. (PH). **Mercer Co.:** 31 Aug 1967, J.M. Fogg s.n. (MOR); 11 Jul 1968, fruit, s.n. (A); 26 May 1970, s.n. (A); 12 May 1973, S.A. & H. Spongberg 73-

220 (A, BM). **Montgomery Co.:** Melrose Park, 15 Jul 1937, C.G. Armstrong s.n. (PH); 20 Aug 1971, fruit, J.M. Fogg s.n. (NY); B. Long 39270 (PH); 29 Jun 1970, Merion, Arboretum of Barnes Foundation, 11 Jun 1980, fruit, J.M. Fogg s.n. (MOR); L.K. Henry s.n. (CM); 19 Feb 1933, Fort Washington Park, A. Zakyzewski & T. Livshultz s.n. (PH). **Philadelphia Co.:** Morris Arboretum, 27 Oct 1967, J.M. Fogg, Jr. s.n. (MOAR, #55-14); 12 Nov 1932, fruit, without collector 969 (MOAR 3 sheets); 1 Jun 1933, 1712 (MOAR 2 sheets); 24 May 1934, 2681 (MOAR); Philadelphia, Lakeside Avenue, 26 Jul 1950, B. Long 71831 (PH). **Northumberland Co.:** Snyder, 27 Sep 1927, H.N. Moldenke 3551 (NY). **Westmoreland Co.:** Greensburg, 1952, C.W. Kalbfus s.n. (CM). **TENNESSEE. Knox Co.:** Knoxville, Agriculture Campus, University of Tennessee, 13 Jun 1972, fruit, P.M. Mazzeo & F.G. Meyer 12858 (MOR, NA); formerly Sanford Arboretum (now property of W. E. Fleury, 3425 Lakeview Dr.), 15 Jun 1972, fruit, P.M. Mazzeo & P.G. Meyer 12913 (MOR, NA). **Franklin Co.:** Winchester, Shadow Nursery, RRI, 6 Jun 1983, F.G. Meyer & P.M. Mazzeo 19765 (CM, MOR, NA). **VIRGINIA. Clarke Co.:** Boyce, 25 May 1970, O. E. White Arboretum, F.G. Meyer & P.M. Mazzeo 12430 (NA); Richmond, 11 Jun 1974, fruit, B.F. Kiltz 540 (NA). **WASHINGTON. King Co.:** Seattle, Washington Park Arboretum, 30 May 1991, J. Canary 94 (NA); 17 Oct 1991, C. Bates 30 (NA). **WASHINGTON, D.C.:** Library of Congress Grounds, Aug 1931, fruit, E.H. Walker 1737 (NA); White House, South Grounds, 22 May 1980, F.G. Meyer & P.M. Mazzeo 17804 (MOR, NA); National Arboretum, 20 Jun 1994, fruit, F.G. Meyer & P.M. Mazzeo 17804 (NA); Tidal Basin, 10 Jun 1977, F.G. Meyer & H. Wester 15918 (MOR); Soldier's Home, University of America, 1938, fruit, F. Baeehle s.n. (NA). **WISCONSIN. Dane Co.:** Madison, 13 Aug 1986, fruit, M. Nee 20818 (NY).

2. *Phellodendron chinense* C.K. Schneid., Ill. Handb. Laubholz. 2:126, fig. 79 c–d, 1907.

Phellodendron amurense f. *longipes* Y.C. Wu

Phellodendron chinense var. *falcatum* Huang, *P. chinense* var. *glabriusculum* C.K. Schneid., *P. chinense* var. *omeiense* Huang, *P. chinense* var. *yunnanense* Huang

Phellodendron fargesii Dode

Phellodendron sinense Dode

Phellodendron sinii Y.C. Wu

Phellodendron chinense was introduced into North America much later, approximately 100 years after it was described in 1907, and much of its introduction to North America as well as to Europe was based on E. H. Wilson's collections from central and southwest China a century ago (Roca-Garcia 1970). This species, however, has not been as popular as *P. amurense*, but cultivated in the gardens and arboreta in Hardiness Zone V (Rehder 1940). It has never been reported as escaped or naturalized.

Original distribution.—Mixed forests, below 2000 m: China (?Anhui, ?Fujian, ?Guangdong, ?Guangxi, ?Guizhou, Hubei, Hunan, ?Jiangsu, ?Jiangxi, Shaanxi, Sichuan, Yunnan, ?Zhejiang. Since the species has been longtime cultivated or naturalized in some places (with “?” before the province) in China, their native distributions or cultivation cannot be obtained with certainty.

Cultivated distribution.—**CANADA:** Ontario. **USA:** Colorado, Massachusetts, New York, Pennsylvania; also in Belgium, England, Germany, Hungary, Ireland, Italy, and Scotland.

Cultivated specimens studied: **U.S.A. MASSACHUSETTS. Suffolk Co.:** Jamaica Plain, Arnold Arboretum, 9 Jun 1982, K. Clausen, S. Davis, C. Warren & M. Awolcott 557 (A, BH, BM, Arnold Arboretum #6963-2-A); 23 Oct 1979, fruit, 79-168 (A, BH, Arnold Arboretum #6963, seed of Wilson 161); 23 Oct 1979, S. Davis, C. Warren & M. Wolcott 79-168 (F, Arnold Arboretum #6963, from seed of Wilson 161 in Changyang Hsien, W. Hupeh, China, Feb. 1908, tree, 50’); 9 Jun 1982, S. Davis et al. 557 (A, Arnold Arboretum #6963-2-A, seed from Wilson, Changyang Hsien, W. Hupeh, China, Feb. 1908); 25 Jun 1969, fruit S. Elsik, B. Mackenzie, A. Kosmidis, & L. Stockman 871 [A, Arnold Arboretum #7245]; 25 Jun 1969, fruit, 874 (A, Arnold Arboretum #6963-A), 5 Sep 1985, fruit, S. Elsik, G. Good & K. Groves 3416 (A, BH, Arnold Arboretum #6963-2-A); 16 Jun 1939, E.J. P. s.n. (A, Arnold Arboretum #6963-1-A); 16 Jun 1892, R. Rehder s.n. (A 3 sheets); 5 Nov 1917, fruit, s.n. (A 2 sheets, Arnold Arboretum #6963); 15 Oct 1917 & 5 Nov 1917, fruit, s.n. (A 2 sheets, Arnold Arboretum #7425); 6 Jun 1918, s.n. (A, Arnold Arboretum #7245); 17 Sep 1918, C.K. Schneider 161 (BKL); 18 Sep 1918, fruit, 876 (BKL) & 17 Oct 1920, fruit (BKL, from Arnold Arboretum #6963). **NEW YORK. Bronx Co.:** Bronx, New York Botanical Garden, 25 Sep 1922, fruit, L.H. Bailey s. n. (BH). **Tompkins Co.:** Ithaca, Cornell University Plantation, 27 Sep 1995, fruit, G.M. Elston 96-3 (BH). **PENNSYLVANIA. Mercer Co.:** Arboretum of Barnes Foundation, 31 Aug 1967, J.M. Fogg Jr. s.n. (BKL); 7 Sep 1970, fruit, s.n. (A, BH). **Philadelphia Co.:** Morris Arboretum, 15 Sep 1959, fruit, J.M. Fogg, Jr. s.n. (MOAR); 14 Mar 1933, fruit, without collector 1351 (MOAR 2 sheets).

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